International Journal on Integrated Education
https://journals.researchparks.org/index.php/IJIE
e-ISSN : 26203502
p-ISSN : 26153785

Theory of Cascade Mining of Open PIT Fields

Samadova Guli Mirzhanovna
PhD in Technical Sciences, Associate Professor, Tajik State Mining Institute
guli1964@list.ru

Tuychiboev Zahriddin Ilhom ugli
Graduate student at Navoi State Mining and Technological University

Annotation: This article examines the difference in the technology of mining operations in conventional and cascade staged development of upland deposits, as well as The difference between the methods of opening from the traditional, without stage development, methods of formation of pillars and their development.

Key words: opening, working horizon, cascade development, half-trench, slope, pillar, and intensification of mining works.

It is possible to improve the mode of mining operations and accelerate commissioning of the open pit by changing the shape of its wall from solid to stepped. But within the framework of stage-by-stage development, keeping the pillars on the wall leads, as it was said before, to decrease intensity of mining operations with the possibility of interruption of mining operations. The task, therefore, is to find a stepped wall design containing ideally no inactive sections. In practice it means mining in steep sections of the wall, which in a classical stage-by-stage development were targets with a long stagnation period.

Recently, in the practice of production and design there has been a tendency to increase the angle of slope of the working side of the quarry. This is achieved in the following ways (Fig. 1):

1) stage-by-stage mining (in the descending order, i.e. "chipping") of the steep section of the working face with one or both flanks when using motor transport (Fig.1, a), the angle of slope of the face at this section can reach 45-50° [1, 2];
2) explosive-mechanized mining of rock mass from the group of overlying benches to the general transport horizon (Fig. 1, б), the angle of slope of the side at the site of the feeding is 40-45 ° [3,4];
3) mining, massif by high (more than 20-40 m) ledges, using excavation equipment with large working parameters (Fig. 1, в), the angle of slope of the wall reaches here 35-40 ° [5,6];
4) dynamic grouping of benches in the working zone with their periodic doubling and stacking (Fig. 1, г), due to which the angle of slope in the grouping area reaches 30-35° [7,8].

e-ISSN : 26203502
p-ISSN : 26153785

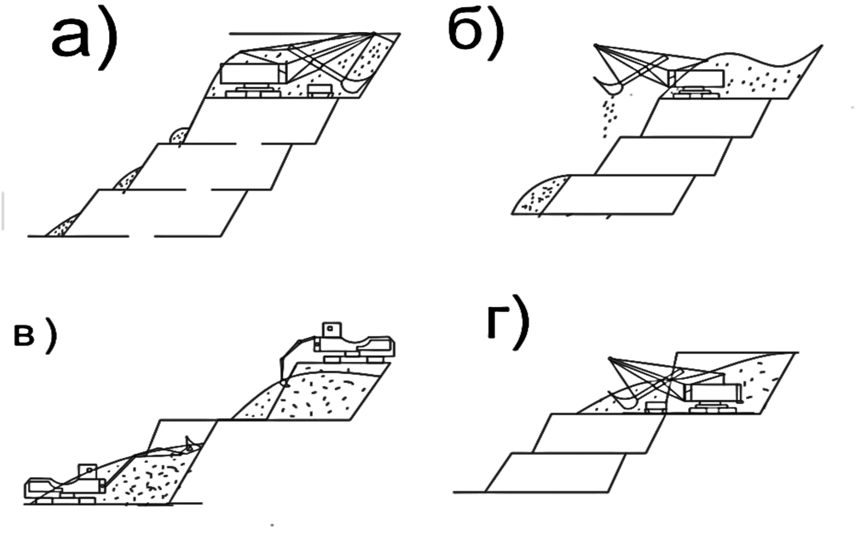

Fig. 1. Schemes of mining the steep pit wall

Let's find out what effect the movement of the steep shoulder (pillar) towards the final contour of the pit has on mining operations. To do this, let's consider the dynamics of development of the shoulder in the area of the lowest pillar. The research is carried out, as above, on graph-analytical model of cross-section profile of the deposit (fig. 2).

Fig. 2 shows the position when the mining operations from the second incision in the slope descended to the rock pillar (point K).

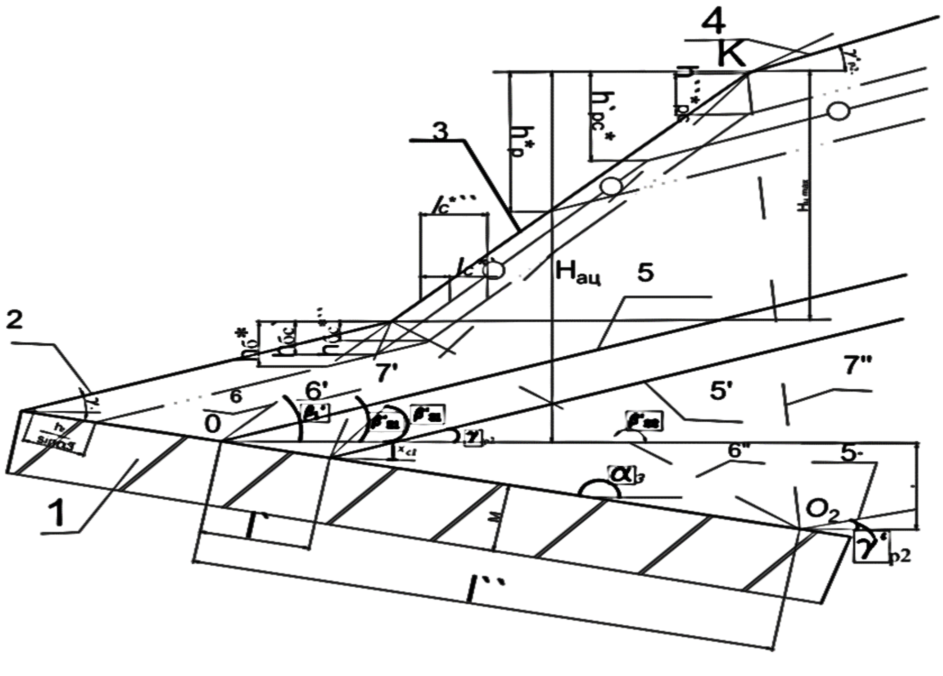

Fig. 2. Pit wall development above the deposit during cascade mining

1 - ore body; 2 and 4 - working board under and over the pillar; 3 - pillar; 5,5′ and 5″ - positions of the board after pillar spreading; 6,6′,6″, 7′ and 7″ - pillar offset lines.

Up to this point, the formation of the target with vertical velocity $h_{б}^{*}$ took place. At the moment when both cuts were connected, the height of the target was $H_{\text{ц мах}}$.

In case of classic stage-by-stage mining, the formation of the pillar will continue according to the same scheme up to the top of the ore body (point 0). At the same time, the pillar will continue to move with vertical speed $h_{\text{р}}^{*}$. Under the condition of compulsory skimming of the pillar over the

e-ISSN : 26203502
p-ISSN : 26153785

top of the ore body, both gently sloping steps of the flank should merge at the same point 0. A different picture will be observed if additional equipment is introduced into the steep part of the flank after the two tie-ins at point K and the former pillar is moved at horizontal speed $l_c^{*'}$. In this case the lower edge of the pillar would be lowered on the ore body (to 0 point) by 6′ line and the upper one - by 7′ line at the position of merged working flank 5′. As a result, an additional strip of ore body of l'width will be exposed. With the same rate of deepening to the ore h_r^* the required speeds of forming and displacement of the moving pillar would decrease respectively to the values $h_6^{*'}$ and $h_{\text{pc}}^{*'}$

If you increase the speed of moving the pillar even more (up to the value of $l_c^{*''}$), the positive effect increases. Then the lower and upper edges of the pillar will move to the deposit along the lines 6″ and 7" to the point 0, respectively. The strip of ore of width l_1'', much larger than l', will open up. The working board will take the 5" position. The required target spreading speeds will decrease even more (to $h_{6_c}^{*''}$ and $h_{\text{pc}}^{*''}$, respectively). If we leave the spreading rate unchanged, it is possible to increase the intensity of mining under the pillar, including in the ore zone, if necessary.

The identified features of wall development will be common to the entire system of moving pillars on the stepped wall of the open pit. The increase in ore reserves is achieved by moving the pillars toward the limiting contour. Creation of an additional controllable link of shifting pillars provides more flexible management of working zone parameters.

The considered procedure of field development is a variation of stage-by-stage development and, unlike its classical variant, can be called cascade development. Here, the steep sections of the slope remain temporarily inactive only until the slope of the adjacent trenches is bridged. After the mining works of the upper gently sloping stage approach to any pillar, it starts working along the front simultaneously with the spread. The pillar (with a decrease in its height) moves along the slip lines, approaching to the roof of the ore body and to the limiting contour of the open pit. Accordingly, such a pillar can be called a sliding pillar as part of cascade mining.

Let's derive calculation formulas for cascade development, using the methods used for similar purposes when describing conventional stage-by-stage development.

The dependence of the required speed of moving the pillar. l_c^* from the preset rate of ore deepening h_r^* is expressed by the formula

$$l_r^* = \frac{h_r^{*} \bullet \sin(\alpha_3 - \gamma_{p1}') \bullet \sin(\beta_2' - \beta_1')}{\sin\alpha_3 \bullet \sin(\beta_2' - \gamma_1'}, \text{ m/year,} \quad (1)$$

where α_3- angle of occurrence, deg; γ_{p1}'- angle of working side under the pillar, deg; β_1'- angle of pillar slope, deg; β_2'- angle of lower pillar shoulder shift, deg.

Convert this formula to find the angle: β_2'

$$l_r^* = \frac{h_r^{*} \bullet \sin(\alpha_3 - \gamma_{p1}') \bullet (ctg\ \beta_1' - ctg\ \beta_2')}{\sin\alpha_3 \bullet \sin\gamma_{p_1}' \bullet (ctg\ \gamma_{p_1}' - ctg\ \beta_2'}, \text{ m/year,} \quad (2)$$

Hence the value of the cotangent angle β_2':

$$\text{ctg}\beta_2' = \frac{h_r^{*} \bullet \sin\left(\alpha_3 - \gamma_{p1}'\right) \bullet ctg\beta_1' - l_c^* \bullet \sin\alpha_3 \bullet \sin\gamma_{p_1}' \bullet ctg\ \gamma_{p_1}'}{x_c + H_{\alpha ц} - H_{цмах}} \quad (3)$$

Formula (3) expresses the relationship between the velocity quantities. We relate the linear quantities to the same angle β_2' through the formula

$$ctg\ \beta_2' = \frac{x_c \bullet ctg\alpha_3 + (H_{\alpha ц} - H_{цмах}) \bullet ctg\beta_1'}{x_c + H_{\alpha ц} - H_{цмах}} \quad (4)$$

Where $x_c = l \bullet \sin\alpha_3$ м; l width of the incremental strip of overburden, m; $H_{\alpha ц}$ - elevation of the cutting into the slope over the top of the ore body (on the slope of the pillar before it shifts), m;

e-ISSN : 26203502
p-ISSN : 26153785

$H_{цмах}$ maximum height of the pillar (at the moment of mining approach to the top edge of the pillar along the slope), m.

Through the cotangent of the angle β_2' we dock the formulas (3 and 4) and obtain an equation linking the velocity and linear parameters of cascade development:

$$ctg\,\beta_2' = \frac{x_c \bullet ctg\alpha_3 + (H_{\alpha ц} - H_{цмах}) \bullet ctg\beta_1'}{x_c + H_{\alpha ц} - H_{цмах}} = \frac{h_r^* \bullet \sin(\alpha_3 - \gamma_{p_1}') \bullet ctg\beta_1' - l_c^* \bullet \sin\alpha_3 \bullet \sin\gamma_{p_1}' \bullet ctg\gamma_{p_1}'}{h_r^* \bullet \sin(\alpha_3 - \gamma_{p_1}') - l_c^* \bullet \sin\alpha_3 \bullet \sin\gamma_{p_1}'} \quad (5).$$

From this equation it is not difficult to obtain explicitly (or iteratively, if we are talking about graphs) the dependences of the studied variables among themselves. Thus,

$$x_c = \frac{(H_{\alpha ц} - H_{цмах}) \bullet (ctg\beta_1' - ctg\beta_2')}{ctg\beta_1' - ctg\alpha_3}, \text{ m} \quad (6)$$

$$H_{aц} = \frac{x_c \bullet (ctg\alpha_ц - ctg\beta_2') + H_{цмах} \bullet (ctg\beta_2' - ctg\beta_1')}{ctg\beta_2' - ctg\beta_1'}, \text{ m} \quad (7)$$

$$H_{цмах} = \frac{H_{aц}(ctg\beta_2' - ctg\beta_1') - x_c(ctg\alpha_3 - ctg\beta_2')}{ctg\beta_2' - ctg\beta_1'}, \text{ m} \quad (8)$$

The speed of cascade development of the target P_c^* is related to the value of its direct horizontal displacement l_c^* by the expression

$$h_p^* = \frac{l_c^* \cdot \sin\beta_1'}{\sin(\beta_2' - \beta_1')} \cdot (\sin\beta_1' \cdot \sin(\beta_2' - \beta_3') \,|\, \sin(\beta_2' - \beta_3') + \sin\beta_2') \text{ m/year.} \quad (9).$$

The value of formation rate $h_{бс}^*$ can be recalculated from the vertical rate of decline along the ore body h_r^*

$$h_{бс}^* = \frac{h_r^* \cdot \sin(\alpha_3 - \gamma'_{p1}) \cdot \sin\beta_2'}{\sin\alpha_3 \cdot \sin(\beta_2 - \gamma'_{p1})}, \text{ m/year,} \quad (10)$$

or - at a known value of l_c^*

It follows from Fig. 2 that in cascade development the speed of formation of sliding pillar will be determined by height

$(H_{aц} + \mathrm{x_c}) - H_{ц\,мах}$, and the rate of spreading - the height $H_{aц} + \mathrm{x_c}$, in contrast to conventional stage-by-stage mining, where the corresponding values are $H_{aц} - H_{ц\,мах}$ and $H_{aц}$. Thus, formation and spreading rates will be determined from the relations: in cascade stage-by-stage development

$$\frac{h_{pc}^*}{h_{бс}^*} = \frac{\mathrm{x_c} + H_{aц}}{\mathrm{x_c} + H_{aц} - H_{ц\,мах}} \quad (11)$$

in the usual step-by-step development

$$\frac{h_p^*}{h_б^*} = \frac{H_{aц}}{H_{aц} - H_{ц\,мах}} \quad (12)$$

From these ratios, you can determine the unknown parameter you are looking for by varying the other quantities.

Literature used:

1. Kudoybergenov K., Aliev Y.M. Establishment of borders of an open pit during development of high-altitude deposits. Mining Journal. -1989 -№ 10. -C 34-36.

2. Mislibayev I.T., Samadova G.M. Research of process of forming and displacement of stepped edge of an open pit at stage-by-stage development of high-mountainous deposits. International Journal of Advanced Technology and Natural Sciences. 2022. № 3(3). -C. 4-10.

3. Gaisinsky M.S., Krasovsky V.G. et al. New Technical Solutions in the Projects of the Institute Uralgiproruda. Mining Journal. -1981 -№ 6. -C 9-12.

e-ISSN : 26203502
p-ISSN : 26153785

4. Samadova G.M., Tuychieva D.I. Technological features of cascade development of mountainous deposits. International Journal of Advanced Technology and Natural Sciences. 2022. № 3(3). -C. 10-16.
5. Grachev A.A. Research of the technology of mining overburden benches with a sub-basement. Cand. dissertation Moscow, 1977. -172 c.
6. Ovodenko B.K., Arshinov S.S. Temporary non-working faces in open pits. L., Nauka. 1997. -218 c.
7. Muratov M.I. Field development by stages with grouping of benches. Collection of Scientific Works. Optimization of Quarry Parameters. Novosibirsk. 1998. -C. 24-32.
8. Mislibayev I.T., Samadova G.M. Development of graph-analytical Model of transverse profile of deposit on slope. Mining Bulletin of Uzbekistan. - Navoi, 2022. - №4. - C. 39-43.